Economic Optima in Soil Conservation Farming And Fertilizer Use for Farms in the Ida-Monona Soil Area of Western Iowa

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CONTENTS

SUMMARY

Soil erosion is a major agricultural problem in western Iowa. While farmers in the area generally are aware of the erosion problem, relatively few use farm plans which result in the level of conservation needed to stabilize soil loss. Previous studies indicate that economic considerations, particularly, retard adoption of soil-conserving sytsems of farming. One problem evidently is that insufficient attention has been devoted to determining erosion-control programs for farmers with different amounts of capital, labor and other resources.

The purpose of this study is to determine profitable erosion-control systems of farming for operators with different amounts of capital and for two different sizes of farms. Emphasis is on profit maximization for the farm as a whole. Since Ida-Monona soils respond readily to fertilization, the plans considered allow an integration of investment in crops, fertilizer and livestock. Specifically, the study is designed to determine the optimum combination of crop rotations, fertilization levels, erosion-control practices and livestock systems. Conservation systems which primarily control erosion either through land cover or mechanical practices are compared by the linear programming technique.

The results of the study show that a combination of (1) rotations which include a maximum of corn within the range of rotations considered, (2) mechanical erosion-control practices (terraces, contouring and listing) and (3) high levels of fertilization provide the most profitable land-use program for most of the capital and resource situations studied. However, in instances where capital, labor or building space are not restricting resources, profits are maximized with a high-forage rotation. This type of rotational program allows maximum profits only at very high capital levels – where grain can be purchased and where the limit to cattle numbers is imposed by forage production.

For "typical" amounts of capital, labor and buildings, investment priority for either 160-acre or 280-acre farms followed this order: (1) crops, (2) fertilizer, (3) hogs and (4) cattle. In other words, the optimum crop program gave the highest return on capital with investment in fertilizer following next. Four fertilization levels were considered for 160-acre farms; three were considered for 280-acre farms. In both cases, the optimum level of fertilization was always the highest level allowed in the programming computations.

Some specific findings of the analysis are these: While erosion control may be achieved either by mechanical practices or by high-forage rotations, greater farm profits generally are allowed by the former. Problems of forage utilization and the need to purchase additional grain depress returns under plans with high-forage rotations. The following relatively high-grain rotations are usually the most profitable cropping alternatives for the specific soil groups considered. CCOM (a corn-corn-oats-meadow rotation) maximizes profits on land of 0-6 percent in slope; CCOM and CCOMM compete closely on soils 7-14 percent in slope; CCOMM ordinarily is optimum on soils 15-20 percent in slope; COMM is used on soils over 20 percent in slope—for such soils COMM is the only rotation considered for which soil losses approach a minimum of 5 tons per acre. The first livestock enterprise to enter plans at low operating capital levels is hogs because they give highest returns per dollar of capital expenditure. Feeder cattle enter optimum plans only when labor and other resources restrict hog production.

Profit-maximizing plans also are computed for farms where buildings must be constructed to allow livestock production. Crops and fertilizer again take priority in the use of limited operating capital. As capital is increased, however, hog buildings can be constructed profitably and hog production expanded. Further increases in capital make investment in beef cattle buildings and production profitable.

Labor limitations influence optimum plans more on 280-acre farms than on 160-acre farms. Hiring additional labor adds little to net profit in a typical 160-acre situation where buildings are already available and where feed is restricted to that grown on the farm. However, in the 280-acre farm situation, high returns are obtained on labor added in critical months. Labor considerations also are important in developing plans to reduce risk on 280-acre farms. Dairy and poultry enterprises, when incorporated in the 160-acre plans, produce only small income sacrifices and can reduce risk without additional hired help. These same enterprises can be included in the 280-acre plans only by hiring large quantities of labor or by accepting a substantial reduction in income. Beef cows appear to be a more practical enterprise for reducing risk on the larger farm.

Farm incomes in the Ida-Monona soil area were drastically reduced by low livestock prices in the fall of 1955. Thus, the influence of various hog-beef cattle price relationships on farm planning and income was investigated. Hog prices could drop nearly 20 percent (with average cattle prices) before a shift in resources away from hogs and toward beef cattle was profitable. An increase of about 20 percent in hog prices (with average cattle prices) did not change the optimum combination of hogs and cattle. The major effect of changing hog prices, within the range considered, was on income rather than planning. Changes in feeding margins for beef cattle, however, required important shifts in farm plans for maximum profits.

In general the findings of this study show that conservation farming systems which include a relatively high corn acreage, mechanical erosion-control practices and heavy fertilization of crops are profitable for typical 160-acre and 280-acre farms in the Ida-Monona soil area. The plans computed for the wide range of resource situations show, however, that programs should vary between farms depending on the available capital, labor and building space.

Economic Optima in Soil Conservation Farming and Fertilizer Use for Farms in the Ida-Monona Soil Area of Western Iowa[1]

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Soil erosion is a major agricultural problem in the Ida-Monona soil area of western Iowa. The physical nature of the problem in relation to farm economics has been discussed elsewhere.[2] While farmers generally are aware of the erosion problem on their own farms, the number of units in the Ida-Monona area with complete soil-conserving farming systems is relatively small. One hypothesis explaining the lack of widespread conservation farming systems is that education and action programs have not sufficiently recognized the need for plans which conform to the capital and resource situation of the individual farm operator.[3] In other words, rather than a single plan for all farms, plans may need to differ by farms according to the supply of capital, labor and other resources of the farm family.

OBJECTIVES AND NATURE OF STUDY

This cooperative study between Iowa State College and the Tennessee Valley Authority is designed to determine the optimum plans for two sizes of farms with varying amounts of operating capital and located in the Ida-Monona soil area of western Iowa. The farm sizes selected are 160 and 280 acres; these sizes are predominate in the area. In Woodbury, Harrison and Monona counties (the three principal counties in the Ida-Monona soil area) the 1954 United States Census of Agriculture for Iowa lists 1,370 farms in the 140-179 acres category and 1,341 farms in the 260-499 acres category, of a total of 6,761 farms. Since Ida-Monona soils generally are responsive to fertilizer, an auxiliary objective of this study is to determine the optimum combination of rotations and fertilization plans for farms in the area. The analysis also allows comparison of income from plans which place different emphasis on mechanical practices and on rotational or cropping system alternatives in control of soil erosion. Alternatives examined for profitability include land-use systems which rely primarily on a large percentage of forage in the rotation to control erosion. Other alternatives include rotations with a smaller percentage of forage and which rely more heavily on mechanical practices such as contouring, terracing and listing for erosion control.

Since farm operators are interested in income from the entire business, the study also attempts to answer this question: Which livestock enterprises combine with the rotation and fertilization system used to provide maximum farm profits? This question is particularly important in western Iowa, where use mainly of forages to control erosion gives rise to large supplies of hay and pasture. Profitable use of hay and pasture products which have low market value unless marketed through livestock, ordinarily requires sizable investment in cattle even for a 160-acre farm. Emphasis on forage production results in a relatively low grain supply per farm. Managers then must decide whether to purchase feed grains or to limit livestock production to feeds grown on the farm.

A large number of farmers in the area studied are restricted in livestock production by the buildings existing on the farm. Optimum plans are determined accordingly. But farmers also ask this question: Under what circumstances is it profitable to invest additional funds in buildings and to enlarge the livestock program? Hence, plans also are determined for situations in which building space and investment can be increased on farms whose programs are restricted mainly to family labor.

The Ida-Monona soil area is one of the "high risk" sections of Iowa. Rainfall for crop production often is inadequate or poorly distributed through the year. Many farmers attempt to attain income stability rather than profit maximization by incorporating low-risk enterprises such as dairy cows, beef cows and poultry in the farming plan. Plans are computed which include these risk precaution restrictions and allow income comparisons with plans where the sole objective is profit maximization.

Farmers recently have been faced with a reduced margin between prices and costs. Specifically, hog prices in 1955 and 1956 were low, both relatively and absolutely, as compared with other Iowa farm products. Hence, an examination is made of optimum combinations of crop and livestock enterprises when hog prices are low relative to beef cattle prices. Effects

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[1] Project 1085, Iowa Agricultural and Home Economics Experiment Station. The authors are indebted to Donald J. Hunter for computing many of the input-output coefficients and farm plans in this study.

[2] Baumann, Ross V., Heady, Earl O. and Aandahl, Andrew R. Costs and returns for soil-conserving systems of farming on Ida-Monona soils in Iowa. Iowa Agr. Exp. Sta. Res. Bul. 429. 1955. Also see: Jensen, Harald R., Heady, Earl O. and Baumann, Ross V. Costs, returns and capital requirements for soil-conserving farming on rented farms in western Iowa. Iowa Agr. Exp. Sta. Res. Bul. 423. 1955.

[3] Frey, John C. Some obstacles to soil erosion control in western Iowa. Iowa Agr. Exp. Sta. Res. Bul. 391. 1952.

on farm plans and profits also are investigated for other hog-beef cattle price relationships.

The empirical method used in this study is linear programming.[4] Briefly, linear programming is a mathematical procedure allowing selection from among many crop and livestock activities and farm practices of the particular combinations which maximize profits—given assumptions with respect to input-output coefficients, to factor and product prices and to resource restrictions. The restrictions imposed on selection of plans are outlined subsequently.

SELECTION OF FARMS

Two actual farm situations in the Ida-Monona soil area were chosen for study.[5] The 160-acre farm is located in Soldier Township and the 280-acre farm in Jordan Township of Monona County. Both farms lie within a single watershed. Eventually all farms in this watershed will be programmed to allow analysis of land treatment in controlling soil loss and water runoff. The farms selected serve as guides in establishing the proportions of various soil types, the quality and size of buildings and the quantity of labor available for farm operation. To provide wider applicability of results, adjustments are made in farm resources where the selected farms differ considerably from the average for the area.

Both farms studied are assumed to be owner-operated. Therefore, the results of this study should be applicable for owner-operators and for cash renters with secure tenure; both groups have the same variable costs and hence the same marginal costs. A profit-maximizing plan will be the same for a particular farmer, whether an owner or cash renter, provided that land, machinery and other resources are held constant. That the owner pays depreciation, taxes and other fixed costs on land and buildings while the renter pays a fixed cash rent is relatively unimportant in short-run farm planning; decisions in either case depend primarily upon variable costs. Hence, only variable costs are used in determining optimum farm plans by use of linear programming.[6] Fixed costs, in general, are ignored because they do not affect resource use in the short run or comparative profits from different plans. However, fixed costs are deducted from the linear programming incomes to adjust the figures to a "net profit" basis. Fixed costs used are $2,397 for 160-acre farms and $3,513 for 280-acre farms, taken from the 1955 "Iowa Farm Record Summary" for western Iowa (see table A-5 in the Appendix).

RESOURCES, PRICES AND PLANNING ALTERNATIVES

Following are the basic data used in this study with respect to resource restrictions, prices and input-output relationships for crop and livestock enterprises.

TABLE 1. ACRES OF CROPLAND OF VARIOUS SOIL TYPES AND SLOPES FOR THE 160-ACRE AND 280-ACRE FARMS.

Percent slope (interval)	Soil type: Ida (acres)	Castana (acres)	Monona (acres)	Napier (acres)	Farm total (acres)
			(160-acre farm)		
0-6	2.8	–	28.0	33.8	64.6
7-14	6.6	–	26.1	–	32.7
15-20	28.6	–	17.1	–	45.7
Farm total	38.0	–	71.2	33.8	143.0
			(280-acre farm)		
0-6	1.0	–	39.0	53.0	93.0
7-14	8.0	–	25.0	–	33.0
15-20	63.0	28.0	10.0	–	101.0
Above 20	26.0	–	–	–	26.0
Farm total	98.0	28.0	74.0	53.0	253.0

LAND

The soil types and slopes on the two farms are presented in table 1 and serve as the land restrictions for the analysis which follows. The 160-acre farm contains a smaller percentage of steeply sloping land than the 280-acre farm. Comparisons in plans and profits between the farm sizes must recognize this difference in soil resources. Table 1 shows the composition by soil type and slope interval of the cropland acreages on the two farms. From soil maps of the two farms the land area is divided into four soil categories (A, B, C and D). As nearly as possible these four soil categories conform to the slope intervals of table 1. That is, A land is approximately 0-6 percent in slope, B land is approximately 7-14 percent in slope, C land is approximately 15-20 percent in slope and D land is over 20 percent in slope. To allow for practical field operations and to avoid fencing problems, the soil classes (A, B, C and D) are not restricted exactly to the boundaries specified by slope interals. Therefore, the acreages in each soil class deviate slightly from the acreages in the slope intervals of table 1. On the 160-acre farm, soil class A contains 68 acres, soil class B contains 46 acres and soil class C contains 29 acres. On the 280-acre farm, soil class A contains 78 acres, soil class B contains 27 acres, soil class C contains 121 acres and soil class D contains 27 acres. To control soil erosion, only certain crop rotations are allowed on each of the soil classes. Details of these rotations and the mechanical practices used with them are presented later.

LABOR

Labor supplies used in programming are given in table 2. These supplies represent modal labor situa-

TABLE 2. HOURS OF LABOR AVAILABLE BY MONTHS FOR 160-ACRE AND 280-ACRE FARMS.

Month	Operator labor for both farm sizes	Family or hired labor: 160-acre farm	Family or hired labor: 280-acre farm	Total labor available: 160-acre farm	Total labor available: 280-acre farm
January	260	26	52	286	312
February	260	26	52	286	312
March	260	26	52	286	312
April	260	26	52	286	312
May	260	40	78	300	338
June	260	130	260	390	520
July	260	130	260	390	520
August	260	130	260	390	520
September	260	40	78	300	338
October	260	26	52	286	312
November	260	26	52	286	312
December	260	26	52	286	312

[4] See: Heady, Earl O. Simplified presentation and logical aspects of linear programming technique. Jour. Farm Econ. 36:1035-50. 1954.

[5] Robert Gray, extension area agronomist, and Everett Stoneberg, extension farm management specialist, assisted in selecting "typical" farm situations in the Ida-Monona soil area.

[6] Exceptions where some fixed costs appear in capital requirements for crops and livestock are explained later.

tions for the two farm sizes. In both cases, operator labor is available for an average of 26, 10-hour days per month. The remaining labor supplies in table 2 are furnished by the family or by hired labor. Net profit figures for the farm plans shown later assume all labor is furnished by the operator and family; if labor is hired, net profit would be diminished accordingly. Labor supplies are greatest during June, July and August when school-age children or hired help normally supplement operator labor. During the summer months, the 280-acre farm becomes essentially a two-man operation.

The family or hired labor supplies have been converted to an operator-equivalent basis. Thus, the labor shown is assumed to be, on an hourly basis, as efficient as operator labor. In addition to the labor supplies of table 2, farm wife labor is available for the poultry enterprise.

The labor restrictions of table 2 are relaxed at various points in the study to observe the effects on farm plans and income when labor is permitted to become nonlimitational. In these situations, the farmer can work extra hours or hire sufficient labor to carry out the resulting farm plans. Again if hired labor is used, net profit figures would be reduced by the amount of wages paid.

OPERATING CAPITAL

Operating capital is a scarce resource on most western Iowa farms. However, not all farmers are faced with the same degree of capital limitation. To provide a basis for recommendations to farmers with varying financial circumstances, plans have been computed for several levels of operating capital (i.e., investment in fixed capital items of land, buildings and machinery must be added to determine total capital) ranging from very limited to nonlimitational amounts.[7] For the 160-acre farm, plans have been computed for operating capital levels of $3,300, $6,600, $9,900, $13,200, $15,000 and nonlimitational capital. Plans have been computed for the 280-acre farm at operating capital levels of $6,000, $12,000, $18,000, $24,000 and $30,000. Operating capital is used primarily for the variable costs associated with crop and livestock production. In addition, operating capital may be used for investment items for which expenditure is made in the current year, such as new buildings or investment in feeder cattle and breeding stock.

The programming steps suppose that the farmer has sufficient machinery for the alternative plans considered (with the exception of the field chopper noted below). Machinery depreciation costs are not included in the capital coefficients for linear programming. However, each rotation is charged with the variable machinery costs associated with planting and harvesting the crops in that rotation. The only exception is that forage harvesting costs are charged against livestock rather than crops since forage is not harvested unless it is fed. Two cattle feeding enterprises use rotation pasture clippings. For these enterprises, a custom charge for a field chopper is included in the capital requirements. This machine ordinarily would not be available or needed on farms with other livestock enterprises.

Two situations with respect to building investment are used in the analysis. Under the first, a typical or modal set of buildings is assumed available on the farm. Livestock enterprises then are limited to the building space available, and no building investment or expense is included in the capital coefficient. Under the second situation, it is assumed that only grain and hay storage facilities exist on the farm. Hence, a building investment charge is included in the capital requirement for each livestock enterprise (i.e., buildings must be constructed before livestock production is feasible). Building investment and livestock production can be increased, given prices and resource restrictions, to the extent that this is the most profitable alternative. Operating capital requirements for livestock under the two building investment situations are presented in table 7.

PRICES

Prices used in the analysis are presented in table 3. The method of pricing attempts to maintain historical price relationships among farm product and cost items, while adjusting prices relative to a corn price of $1.33 per bushel (the 1955 market price in the area). The adjustment procedure consists of finding the ratio of the average price of each item to the average corn price for a given time period and multiplying this ratio by a $1.33-per-bushel price for corn. The time period used for all items except feeder cattle and hogs is 1950-55. Feeder cattle and hog prices are computed for historical base periods of 1935-55 and 1947-55 respectively.

Table 3 lists per-unit prices for various items. Gross return per unit of each crop and livestock enterprise is found by multiplying total production of the enter-

TABLE 3. PRICES USED IN THE ANALYSIS.

Item	Weight (lbs.)	Time of transaction	Unit	Prices ($)
Yearling feeder steers	650	November	cwt.	22.21
Steer feeder calves	450	October	cwt.	23.68
Choice fat cattle	1,070	September	cwt.	26.47
Choice fat cattle	1,120	November	cwt.	26.23
Choice fat cattle	950	November	cwt.	27.10
Choice fat cattle	1,000	December	cwt.	26.08
Veal calf	–	Annual	cwt.	21.87
Cull cow	1,000	Annual	cwt.	14.88
Beef breeding cow (inventory)	1,100	Annual	cwt.	18.36
Dairy cow (inventory)	1,000	Annual	head	188.95
Breeding gilts	350	Annual	cwt.	17.75
Barrows and gilts	225	March	cwt.	18.43
Barrows and gilts	225	September	cwt.	19.87
Old sows	350-450	May-June	cwt.	16.98
Corn (selling)	–	Annual	bu.	1.33
Corn (buying)	–	Annual	bu.	1.43
Oats	–	Annual	bu.	0.70
Soybeans	–	Annual	bu.	2.48
Eggs	–	Annual	doz.	0.34
Farm chickens	–	Annual	lb.	0.18
Laying mash	–	Annual	cwt.	4.92
Soybean oilmeal	–	Annual	cwt.	4.40
Baby chicks	–	Spring	100 head	28.90
Artificial insemination	–	Annual	1 service	7.00
Boar service	–	Annual	per sow	2.00
Butterfat	–	Annual	lb.	0.62
Phosphoric acid	–	Spring	cwt.	11.00
Nitrogen	–	Spring	cwt.	14.40
Muriate of potash	–	Spring	cwt.	5.40

[7] With a nonlimitational capital level, other resources limit the plan before capital becomes restricting. Essentially, the capital equation is removed from the linear programming matrix.

prise by the appropriate product prices of table 3. The net return for each activity used in programming then is found by deducting operating costs (exclusive of investment items) from gross price for the enterprise. *Net return* is used in this study to refer to gross return minus operating costs. *Net profit* is obtained by subtracting fixed costs from net return.

ROTATIONS AND YIELDS

Table 4 shows the crop rotations considered as alternatives on each of the various soil classes. Intensive grain rotations are limited to the less sloping and more productive soils, while less intensive rotations are allowed on all cropland. Soil erosion control practices and estimated soil losses are specified for each rotation-soil class combination. Four of these combinations in table 4 permit soil losses slightly exceeding the generally accepted allowable level of 5 tons per acre per year. Soil losses in excess of 5 tons per acre per year may reduce yields (1) because of the removal of large quantities of plant nutrients in the runoff water, (2) because the water that causes the erosion will be lost as runoff and will not be available for use by plants and (3) because local areas of washing and silting within the field frequently result in poor stands of grain crops. However, the soil losses of table 4 probably would not be sufficiently great to permit serious on-site gullying.

Agronomic experiments in the Ida-Monona soil area indicate that fertilization of corn and oats generally is a profitable investment. Table 5 presents crop yield estimates for the various rotations and soil types under conditions of (a) no fertilization, (b) low fertilization, (c) medium fertilization and (d) high fertilization.[8] These yields are adjusted for different degrees of slope before use in the programming analysis to follow.[9] All four fertilization treatments (from no fertilizer to the third or high fertilizer rate) are considered as alternatives for the 160-acre farm situation. However, many farmers view high fertilization, although profitable on the average, as risky because of uncertain moisture conditions. Therefore, in computing plans for the 280-acre farm, the high fertilizer rate is omitted.

Table 6 presents the operating capital and labor requirements (excluding fertilizer treatment) for the various crops. "Constant" costs per acre (not to be confused with fixed costs) are those operating costs which are incurred in planting and cultivating crops, regardless of yield. "Variable" costs are operating costs which vary directly with per-acre crop yields. The costs in table 6, plus fertilizer costs, constitute the total operating costs (i.e., fixed costs of machinery and buildings are excluded) per acre of the various rotations used in programming. Net return to the various rotations is computed by subtracting total operating costs from gross return per acre.

LIVESTOCK ENTERPRISES

The following 13 livestock enterprises are included as alternatives in planning for both farm sizes:

A. *Yearling feeder steers.*

(1) Good-choice yearling feeder steers, purchased at 650 pounds in November, wintered, full-fed on drylot and sold at 1,070 pounds in September.

(2) Good-choice yearling feeder steers handled the same as in system (1), except full-fed on pasture.

(3) Good-choice yearling feeder steers purchased at 650 pounds in November, wintered, grazed 60 days on pasture, then full-fed and sold in November at 1,120 pounds.

(4) Good-choice yearling feeder steers purchased at 650 pounds in November, wintered, fed limited corn plus green clippings in drylot for 80 days, then full-fed and sold in November at 1,120 pounds.

B. *Feeder calves.*

(5) Good-choice calves purchased at 450 pounds in October, wintered, full-fed on drylot and sold at 950 pounds in November.

(6) Good-choice calves purchased at 450 pounds in October, handled the same as in system (1) except full-fed on pasture and sold in November.

(7) Good-choice calves purchased at 450 pounds in October, wintered, grazed 60 days on pasture, then full-fed and sold at 1,000 pounds in December.

[8] See footnotes, table 5 for assumptions underlying the yield estimates.

[9] The yields in table 5 are for representative slopes within each soil type. For Ida soils the representative slope range was assumed to be 7-14 percent; for Castana soils, 15-20 percent; for Monona soils, 7-9 percent; and for Napier soils, 2-6 percent. Where slopes within a particular soil type deviated from this representative range, adjusted corn yields were estimated as a percentage of the yields in table 5 (e.g., 70 percent, 90 percent, 105 percent, etc.). Yields of oats, soybeans and meadow were not adjusted for slope. It is recognized that yields also may be lower on the more eroded phases of some soil types. However, adjustments in yields were not made for soils of different erosion classes.

TABLE 4. ROTATIONS AND EROSION CONTROL PRACTICES FOR VARIOUS CLASSES OF SOIL, WITH SOIL LOSS IN TONS PER ACRE PER YEAR ESTIMATED BY BROWNING'S EROSION FACTORS.*

Rotation and soil class†	Erosion control practices used	Browning's erosion factors: Soil factor	Percent slope	Slope length	Degree of erosion	Soil fertility practices	Rotation	Supplemental practices	Estimated tons of soil loss per acre per year‡
COMM-A	Contouring	1.25	0.5	2.0	1.0	1.0	0.58	0.50	2.9
COMM-B	Terracing	1.25	1.9	2.0	1.3	1.0	0.58	0.12	3.4
COMM-C	Terrace-listing	1.50	3.1	2.0	1.3	1.0	0.58	0.10	5.6
COMM-D	Terrace-listing	1.50	3.1	2.0	1.3	1.0	0.58	0.12	6.7
COM-A	Contouring	1.25	0.5	2.0	1.0	1.0	0.89	0.50	4.5
COM-B	Terrace-listing	1.25	1.9	2.0	1.3	1.0	0.89	0.07	3.1
COM-C	Terrace-listing	1.50	3.1	2.0	1.3	1.0	0.89	0.10	8.6
CCOMM-A	Contouring	1.25	0.5	2.0	1.0	1.0	0.97	0.50	4.8
CCOMM-B	Terrace-listing	1.25	1.9	2.0	1.3	1.0	0.97	0.06	2.9
CCOMM-C	Terrace-listing	1.50	3.1	2.0	1.3	1.0	0.97	0.07	6.6
CCOM-A	Contour-listing	1.25	0.5	2.0	1.0	1.0	1.38	0.25	3.5
CCOM-B	Terrace-listing	1.25	1.9	2.0	1.3	1.0	1.38	0.06	4.1
CSbOM-A	Contour-listing	1.25	0.5	2.0	1.0	1.0	1.38	0.25	3.5

* Browning's erosion factors; estimates developed by Department of Agronomy, Iowa State College, Ames, Iowa. Revised Feb. 1957. (Mimeo.)

† The rotation symbols have this meaning: C=corn, O=oats, M=meadow and Sb=soybeans. For example, COM is a corn-oats-meadow rotation. The letters A, B, C and D refer to soil classes defined in the section entitled "Land."

‡ Estimated tons of soil loss per acre per year is the product of the various Browning erosion factors multiplied by 8. For example, the estimated soil loss for COMM-A above is 8(1.25x0.5x2.0x1.0x1.0x0.58x0.50)=2.9.

TABLE 5. CROP YIELD ESTIMATES BY SOIL TYPES, BY ROTATIONS AND FERTILIZER RATES.*

Rotation	Crop	Soil type	No treatment yield†	First or low fertilizer rate: Rate	Yield†	Second or medium fertilizer rate: Rate	Yield†	Third or high fertilizer rate: Rate	Yield†
COM	Corn	Ida	19	0-20-0	30	30-50-0	43	40-60-0	52
		Castana	48	0-10-0	54	10-20-0	59	20-40-0	62
		Monona	56	0-10-0	63	10-20-0	72	20-30-0	77
		Napier	62	0-10-0	68	5-20-0	72	20-20-0	77
	Oats	Ida	15	0-20-0	18	20-50-0	28	20-60-0	34
		Castana	28	0-20-0	33	10-20-0	38	20-40-0	40
		Monona	30	0-20-0	34	10-20-0	39	20-30-0	40
		Napier	43	‡	43	10-20-0	45	20-20-0	45
	Meadow	Ida	0.5	‡	1.0	‡	1.8	‡	2.0
		Castana	1.1	‡	2.0	‡	2.5	‡	2.7
		Monona	1.3	‡	2.0	‡	2.5	‡	2.8
		Napier	2.0	‡	2.0	‡	3.0	‡	3.0
COMM	Corn	Ida	20	0-20-0	30	30-50-0	45	40-60-0	52
		Castana	50	0-10-0	55	10-20-0	60	20-40-0	63
		Monona	58	0-10-0	64	10-20-0	72	20-30-0	78
		Napier	65	0-10-0	69	5-20-0	74	20-20-0	78
	Oats	Ida	15	0-40-0	20	20-50-0	28	20-80-0	35
		Castana	32	0-30-0	34	10-40-0	40	10-40-0	40
		Monona	36	0-20-0	36	10-30-0	40	10-40-0	40
		Napier	43	0-15-0	45	0-20-0	45	10-30-0	45
	Meadow	Ida	0.6	‡	1.0	‡	1.5	‡	2.1
		Castana	1.1	‡	1.6	‡	2.4	‡	2.9
		Monona	1.3	‡	1.8	‡	2.5	‡	2.8
		Napier	2.0	‡	2.0	‡	2.8	‡	3.0
CCOMM	Corn	Ida	19	15-15-0	30	30-50-0§	42	40-60-0**	51
		Castana	48	10-10-0	53	25-25-0	58	35-40-0	61
		Monona	56	10-10-0	62	25-20-0	71	30-30-0	76
		Napier	62	10-10-0	66	20-20-0	71	25-20-0	76
	Oats	Ida	15	0-40-0	18	20-60-0	28	0-80-0	34
		Castana	28	0-30-0	33	10-40-0	38	10-40-0	40
		Monona	30	0-20-0	34	10-30-0	39	10-40-0	40
		Napier	43	0-15-0	43	0-20-0	45	10-30-0	45
	Meadow	Ida	0.6	‡	1.0	‡	1.5	‡	2.0
		Castana	1.1	‡	1.4	‡	2.1	‡	2.8
		Monona	1.3	‡	1.6	‡	2.3	‡	2.8
		Napier	2.0	‡	2.0	‡	2.8	‡	3.0
CCOM	Corn	Ida	18	20-20-0	28	30-50-0§	40	40-60-0††	50
		Castana	45	15-10-0	49	35-20-0	56	45-40-0	60
		Monona	53	15-10-0	58	35-20-0	70	40-30-0	75
		Napier	58	10-10-0	64	30-20-0	70	35-20-0	75
	Oats	Ida	15	0-20-0	20	20-40-0	28	0-60-0	33
		Castana	28	0-20-0	30	10-20-0	36	20-40-0	40
		Monona	30	0-20-0	33	10-20-0	38	20-30-0	40
		Napier	43	‡	43	10-20-0	45	20-20-0	45
	Meadow	Ida	0.5	‡	1.0	‡	1.8	‡	2.0
		Castana	1.1	‡	2.0	‡	2.5	‡	2.7
		Monona	1.3	‡	2.0	‡	2.5	‡	2.8
		Napier	2.0	‡	2.0	‡	3.0	‡	3.0
CSbOM	Corn	Ida	18	10-20-0	28	30-50-0	40	40-60-0	50
		Castana	45	5-10-0	50	15-30-0	56	30-40-0	60
		Monona	53	0-10-0	61	10-20-0	70	20-30-0	75
		Napier	58	0-10-0	65	10-20-0	73	15-20-0	75
	Soybeans	Ida	10	‡	12	‡	15	‡	15
		Castana	12	‡	14	‡	18	‡	18
		Monona	15	‡	17	‡	20	‡	20
		Napier	25	‡	26	‡	30	‡	30
	Oats	Ida	15	0-20-0	22	20-40-0	30	20-60-0	33
		Castana	30	0-20-0	33	5-20-0	38	10-40-0	40
		Monona	32	0-20-0	35	5-20-0	40	10-30-0	40
		Napier	43	‡	44	5-20-0	45	20-20-0	45
	Meadow	Ida	0.5	‡	1.0	‡	1.8	‡	2.0
		Castana	1.1	‡	1.8	‡	2.5	‡	2.7
		Monona	1.3	‡	2.0	‡	2.5	‡	2.8
		Napier	2.0	†	2.5	‡	3.0	‡	3.0

* Crop yields and fertilizer rates are an average of 2 years when crops succeed themselves, except where indicated otherwise. It is assumed that management systems have been in operation long enough for yields to reflect the major effects of applied practices. Yields are based on average weed, disease and insect control as well as average weather conditions. Good drainage control of erosion also are assumed. Yield estimates are provided by the Department of Agronomy, Iowa State College.

† Corn and oats yield in bushels per acre, hay in total tons per acre.

‡ No fertilizer treatment added.

§ Fertilizer rate for second-year corn is 60-50-0.

** Fertilizer rate for second-year corn is 80-60-0.

†† Fertilizer rate for second-year corn is 100-60-0.

TABLE 6. OPERATING CAPITAL AND LABOR REQUIREMENTS PER ACRE FOR VARIOUS CROPS.*

Resource requirements	Corn	Oats	Soybeans	First-year meadow†			Second-year meadow†		
				Pasture	Baled	Chopped	Pasture	Baled	Chopped
"Constant" cost (dollars)‡	17.08	13.11	17.06	7.66	18.70	18.25	5.15	16.19	15.74
"Variable" cost (dollars)§	0.08**	0.05**	0.05**	—	2.75††	1.50††	—	2.75††	1.50††
Labor (in hours per acre)									
March	—	0.36	—	—	—	—	—	—	—
April	1.18	0.90	0.59	—	—	—	—	—	—
May	2.20	—	1.46	—	—	—	—	—	—
June	1.31	—	0.87	—	6.22	6.22	—	6.22	6.22
July	1.07	1.88	0.67	—	5.30	5.30	—	5.30	5.30
August	—	1.88	—	—	—	—	—	—	—
September	0.20	—	0.17	—	4.48	4.48	—	4.48	4.48
October	1.48	—	2.24	—	—	—	—	—	—
November	2.04	—	—	—	—	—	—	—	—
December	0.52	—	—	—	—	—	—	—	—

* All operating costs and labor requirements are for situations in which no fertilizer is applied.
† Costs and labor for planting meadow are included in oats nurse crop.
‡ "Constant" costs refer to operating costs which are independent of yield, such as fuel and seed costs.
§ "Variable" costs include operating costs such as hauling and elevating which vary with crop yields.
** Per bushel of grain.
†† Per ton of hay.

(8) Good-choice calves purchased at 450 pounds in October, wintered, fed limited corn plus green clippings on drylot for 80 days, then full-fed and sold in December at 1,000 pounds.

C. Beef herd.

(9) Beef breeding herd with a 90-percent calf crop sold as good-choice feeder calves in October at 450 pounds. Herd replacement rate is 12.5 percent.

D. Hogs.

(10) Two-litter system with equal numbers of spring and fall pigs (7.08 pigs per litter) and hogs sold at 220 pounds. Pigs farrowed in March and September and sold 6 months later.

(11) Spring litters only with hogs farrowed in March and sold in September at 220 pounds.

E. Dairy cows.

(12) Butterfat-producing dairy herd. Cows produce an average of 323 pounds of butterfat sold as cream. Replacement rate for cows in the herd is 22.4 percent.

F. Poultry.

(13) Supplemental poultry enterprise producing both eggs and young farm chickens. Hens produce an average of 172 eggs annually. Cull hens are considered a product.

Conservation farming, even with adequate mechanical practices, requires production of large quantities of forage. This forage has a low return unless processed through livestock. Thus, a variety of beef enterprises (eight beef-cattle feeding activities and a beef-cow herd) are included as possibilities in forage utilization. Although the dairy enterprise also utilizes large quantities of forage, it is considered only for certain situations where it is forced into the plan as a risk precaution. Under other situations, poultry as well as dairy cows are forced into the farm program on a moderate scale to spread risk through diversification.

Input-output coefficients for the various livestock enterprises are summarized in table 7. As mentioned previously, costs and labor for hay harvesting are included in coefficients for forage-consuming livestock enterprises. Capital requirements are shown for the two building situations: (1) where a typical or modal set of buildings is available and no additional building investment is required and (2) where no livestock buildings are available and a building investment charge is included in the capital requirements for livestock enterprises. Total capital for each livestock activity is the sum of annual operating costs and the appropriate investment figure, depending on the building situation considered.[10] For example, under building situation (1), total capital for yearling steers on drylot (table 7) is found by adding "annual operating costs" and "investment excluding buildings" ($178.13+$13.50=$191.63). Net returns for each activity are the same under either building situation; only the total capital requirement changes. Net returns show the excess of gross returns over annual operating costs (which include the value of grain fed and feeders purchased but exclude investment items and other fixed costs).

In this analysis, corn and oats are sold for cash or fed to livestock, depending on maximum profitability for the farm as a whole. Purchase price for feed grain is higher than sale price because of handling and transportation costs. In a few situations, it is assumed that the farmer would not buy feed grain because of risk considerations. That is, some livestock farmers view purchase of grain at market prices as more risky than growing feed on the farm. Soybeans are sold for cash, while hay is fed or goes unused with no direct cash return.

INTERPRETATION OF MAXIMUM-PROFIT PLANS FOR 160-ACRE FARM SITUATIONS

This section includes presentation and interpretation of plans for 160-acre farm situations. An operator and family labor supply[11] is used for all 160-acre situations except one—the special case when labor is nonlimitational. Building restrictions (made explicit at each point) vary with the situation and are: (1) A typical or modal set of buildings already on the farm with livestock enterprises limited to the available space [12] and (2) no livestock buildings on the farm, requiring investment in buildings for livestock production. Under the latter situation, buildings do not restrict the size of the livestock enterprise and can be expanded as long as the investment is consistent with maximum profit for the farm as a whole.

PLANS FOR A "TYPICAL" SITUATION

Optimum farm plans are presented first for a situ-

[10] This building investment charge is one of the exceptions mentioned earlier where some "fixed costs" enter the operating capital requirement.

[11] This labor supply is the sum of operator and family or hired labor shown in table 2.

[12] A typical or modal set of buildings for the 160-acre farm provides 720 square feet of hog space and 1,960 square feet of cattle space.

TABLE 7. INPUT-OUTPUT RELATIONSHIPS FOR THE LIVESTOCK ENTERPRISES INCLUDED IN THE STUDY.*

Item	Unit	Yearling steers on drylot (1 head)	Yearling steers on pasture (1 head)	Yearling steers deferred feeding (1 head)	Yearling steers fed clippings (1 head)	Steer calves on drylot (1 head)	Steer calves on pasture (1 head)	Steer calves deferred feeding (1 head)	Steer calves fed clippings (1 head)	Beef breeding cows (1 cow)	Two-litter hog system (2 litters)	Spring litter hog system (1 litter)	Dairy cows (1 cow)	Poultry (100 hens)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Purchase date	—	Nov. 1	Nov. 1	Nov. 1	Nov. 1	Oct. 15	Oct. 15	Oct. 15	Oct. 15	—	—	—	—	—
Selling date	—	Sept. 15	Sept. 15	Nov.1	Nov. 1	Nov. 1	Nov. 1	Dec. 1	Dec. 1	—	Sept. & Mar.	Sept.	—	—
Purchase weight	lbs.	650	650	650	650	450	450	450	450	—	—	—	—	—
Selling weight	lbs.	1,070	1,070	1,120	1,120	950	950	1,000	1,000	504	3,139	1,660	—	—
Corn equivalent†	bu.	55.0	55.0	50.0	45.0	65.0	68.0	52.0	52.0	6.7	190.0	100.0	40.8	162.7
Supplement	lbs.	200	—	50	50	400	120	125	125	—	1,000	530	315	4,199
Hay	tons	1.7	1.4	1.5	1.5	1.0	0.8	0.8	0.9	1.2	0.7	0.5	3.2	—
Pasture	acres	—	0.5	0.8	—	—	0.3	0.6	—	1.8	—	—	1.2	—
Green clippings‡	tons	—	—	—	3.2	—	—	—	2.6	—	—	—	—	—
Labor:														
January	hrs.	0.5049	0.6080	0.6080	0.5049	1.0092	1.0092	1.0092	1.0092	2.0400	4.4840	0.8810	13.64	15.96
February	hrs.	0.5049	0.5890	0.5890	0.5049	0.9918	0.9918	0.9918	0.9918	2.0400	4.4840	1.8810	13.02	15.96
March	hrs.	0.5049	0.5890	0.5890	0.5049	0.9918	0.9918	0.9918	0.9918	2.2650	11.6230	7.5900	13.64	17.22
April	hrs.	0.5049	0.3040	0.5890	0.5049	1.3920	2.5025	0.9918	1.3920	1.5300	5.6050	1.9140	11.78	20.58
May	hrs.	2.4939	3.0970	0.3040	3.1093	2.5056	2.5056	1.3920	3.1210	0.7650	3.5990	1.9140	9.30	31.71
June	hrs.	6.9026	6.7277	6.9870	9.7742	5.0989	4.5803	4.5803	7.5815	3.7473	3.3040	2.7390	7.44	22.05
July	hrs.	6.2486	6.1891	6.4100	8.4779	4.7143	4.2725	4.2725	6.6122	3.3050	3.3040	2.7390	7.44	17.22
August	hrs.	2.4839	3.0970	3.0970	2.4939	2.5056	2.5056	2.5056	2.5056	0.7650	3.3040	2.1450	8.06	15.96
September	hrs.	4.4167	4.1590	5.8940	7.2861	4.3703	3.9973	3.9973	5.7128	2.9094	6.0770	4.0260	7.44	15.33
October	hrs.	—	—	3.0970	2.4939	3.4974	2.5056	3.4974	3.4974	0.7650	4.7790	2.1450	9.30	12.18
November	hrs.	0.3060	0.4180	0.4180	0.3060	0.9918	0.9918	3.4974	3.4974	1.0050	3.9530	2.1450	10.54	13.65
December	hrs.	0.3060	0.4180	0.4180	0.3060	1.0092	1.0092	1.0092	1.0092	1.5300	4.4840	1.8810	12.40	12.18
Building space requirement	sq. ft.	40	40	40	40	30	30	30	30	50	71	42	84	412
Annual operating costs	$	178.13	166.65	170.38	181.39	143.76	129.65	130.51	139.90	19.66	135.78	58.26	35.08	285.71
Investment excluding buildings	$	13.50	13.50	13.50	53.50	13.50	13.50	13.50	53.50	242.35	95.85	93.64	204.10	100.00
Investment including buildings	$	76.20	72.90	74.00	114.00	57.50	55.30	55.30	95.85	310.00	160.85	158.64	—	—
Total capital excluding buildings	$	191.63	180.15	183.88	234.89	157.26	143.15	144.01	193.40	262.01	231.63	151.90	239.18	385.71
Total capital including buildings	$	254.33	239.55	244.38	295.39	201.26	184.95	185.81	235.75	329.66	296.63	216.90	—	—
Net return	$	31.95	43.43	56.90	52.54	27.24	37.36	61.13	51.74	77.64	196.48	120.97	207.30	77.89

* Feed requirements were furnished by the Department of Animal Husbandry, Iowa State College. Labor and capital requirements were synthesized from various sources, including estimates by the Department of Agricultural Engineering, Iowa State College.

† Oats were converted to corn equivalent feed value on the basis of 2 bushels of oats equal to 1 bushel of corn.

‡ Green clippings were converted to hay equivalent on the basis of 1 ton of clippings equal 0.33 ton of hay.

ation in which resource restrictions correspond with those on a "typical" 160-acre farm. Table 8 summarizes the optimum farm plans at various levels of operating capital for a 160-acre farm with labor and building supplies which are representative of farms of this size in the soil area. With a low level of operating capital ($3,300), soil classes A and B (0-14 percent in slope) are planted to $CCOM_3$[13], and soil class C (15-20 percent in slope) is planted to $CCOMM_3$ for maximum profits.[14] These rotations and fertilization rates form the optimum cropping plan for all capital levels in the "typical" situation (table 8). Later tables show that this cropping and fertilization plan outcompetes all others for the 160-acre farm except where another system is forced on the land. In other words, rotations with the maximum of corn allowed and with relatively little forage enter the plan for each soil class at all levels of operating capital. There is some question concerning the feasibility of the 5-year rotation ($CCOMM_3$) on only 29 acres of C soils. This cropping plan would require modification to allow adequate field sizes and practical field operations. On the other hand, the plans do indicate that profits are maximized on the less productive soils by using rotations which are less grain-intensive than those on A and B soils.

The third level of fertilization occurs at all capital levels, denoting this as one of the most productive investment opportunities. Even when capital is so limited that either fertilization or livestock must be omitted from the plan, fertilization at the third level is a more profitable use of operating capital. Livestock do not enter the plan with only $3,300 in operating capital. The two rotation-fertilization systems shown provide greater returns per dollar of operating capital than any livestock enterprise, even though hay has no direct cash return.

[13] The subscript following the rotation denotes the fertilizer rate. For example, $CCOM_3$ is a corn-corn-oats-meadow rotation fertilized at the third rate.

[14] On land of more than 14 percent in slope, the back slopes of terraces are too steep to be farmed. For this reason approximately 10 percent of the land area of this slope would be removed from crop production. While the plans of this study do not make this adjustment, the result would be to slightly reduce crop and livestock production and lower net profits accordingly.

When operating capital is increased to $6,600 for a 160-acre farm (table 8) the livestock program includes 20 litters of pigs produced under the two-litter system and a small feeding enterprise of seven deferred-fed steer calves. The two-litter hog enterprise enters the plan first because it has a higher return per dollar of operating capital than other livestock enterprises. When the hog enterprise expands to the 20-litter maximum allowed by building space, deferred-fed steer calves enter the optimum plan. This beef enterprise has greater returns on capital than other beef enterprises but lower returns compared with the hog enterprises. Thus, to maximize profits, priority for use of limited funds is: first, investment in machinery and crop expenses to get crops planted; second, investment in fertilizer; third, investment in hogs; and fourth, investment in cattle.

These plans appear reasonable and practical from the viewpoint of a farmer with a relatively low level of capital and a limited quantity of operator and family labor. The plans allow a sizable volume of business with rather limited funds. Also, farmers in this capital group presumably are interested in low-risk livestock enterprises, such as those included in the plans. At the $9,900 and nonlimitational levels of operating capital, expansion of livestock production allows greater profits but entails more risk. The beef-feeding enterprises, high in risk relative to crop and hog production, expand in size at the higher capital levels. A shift to the one-litter hog system reduces the degree of marketing diversification inherent in the two-litter system.[15] That is, marketings under the two-litter system are divided between March and September; they are concentrated in September under the one-litter system.

At the nonlimitational capital level, yearlings fed on clippings enter the plan because they provide high returns on limited November labor. However, if two types of feeder enterprises appear impractical, profits

[15] The shift from the two-litter to the one-litter hog system at the nonlimitational capital level is caused by a shortage of labor in November. A shift to the one-litter system frees fall labor, permitting expansion of the cattle-feeding enterprises.

TABLE 8. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A "TYPICAL" 160-ACRE SITUATION.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$3,300	A,B,C land Capital	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	No livestock		5,315 bu. sold	$1,420
$6,600	A,B,C, land Capital Hog space	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	20 litters 7 head	3,035 bu. sold	$3,805
$9,900	A,B,C land Capital Hog space	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	20 litters 30 head	1,844 bu. sold	$5,206
Nonlimitational capital = $12,369	A,B,C land Hog space July labor Nov. labor	Same cropping system as for $3,300 capital					One-litter hog-system Deferred-fed calves Yearlings fed clippings	17 litters 30 head 9 head	1,592 bu. sold	$5,826

* Assuming an operator and family labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm.

† Net profit = gross return − (variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

TABLE 9. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 160-ACRE SITUATION WHERE LABOR IS NONLIMITATIONAL.*

Operating capital used	Limiting resources	Cropping system: Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Livestock program: Size	Corn purchased or sold	Net profit†
$3,300	A,B,C land Capital	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	No livestock		5,315 bu. sold	$1,420
$6,600	A,B,C land Capital Hog space	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	20 litters 7 head	3,035 bu. sold	$3,805
$9,900	A,B,C land Capital Hog space	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	20 litters 30 head	1,844 bu. sold	$5,206
$13,200	A,B,C land Capital Hog space Hay	Same cropping system as for $3,300 capital					One-litter hog system Deferred-fed calves Calves fed clippings	17 litters 30 head 16 head	1,240 bu. sold	$6,098
$15,000	A,B,C land Capital Hog space Hay	Same cropping system as for $3,300 capital					One-litter hog system Deferred-fed calves Calves fed clippings	17 litters 13 head 38 head	977 bu. sold	$6,202
Nonlimitational capital=$16,385	A,B,C land Hog space Hay	Same cropping system as for $3,300 capital					One-litter hog system Calves fed clippings	17 litters 54 head	775 bu. sold	$6,283

* Assuming a nonlimitational labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm.

† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

can be maintained at nearly the same level by using 30 hours more labor in November and replacing the nine yearlings by eight additional deferred-fed calves. Given the resource restrictions of table 8, increases in capital beyond $12,369 will not alter the optimum farm plan nor increase income. Only when one or more of the other resource restrictions are lifted can income be increased further.

Again, the optimum plans at the upper capital levels of table 8 appear consistent with risk considerations. Farmers with these levels of operating capital generally are able to shoulder greater risk without the possibility of bankruptcy. Some farmers, however, may attain the higher levels of operating capital through use of borrowed funds. In this situation, because of the increasing risk principle, the operator rationally may adopt a less than optimum plan involving less risk. In any situation where borrowed funds are used, interest charges should be included as a cost in computing net profits.

PLANS FOR A NONLIMITATIONAL LABOR SUPPLY

Some farmers have exceptionally large quantities of family labor available or can readily hire hourly labor. As a guide for such farmers, plans are computed for a 160-acre situation assuming nonlimitational labor (see table 9). A typical operator and family labor supply does not restrict plans at lower capital levels. Thus, the plans of table 8 (operator and family labor) and table 9 (nonlimitational labor) are identical at the $3,300, $6,600 and $9,900 levels of operating capital. However, beyond $9,900 in operating capital, nonlimitational labor allows use of more capital and gives greater net profit. The one-litter hog system dominates at higher capital levels because it produces greater returns given the limited hog building space. Deferred-fed calves and calves fed clippings enter the plans because they are the most efficient beef enterprises in the use of capital and hay, respectively. Thus, calves fed clippings increase and finally replace deferred-fed calves as hay becomes more limiting relative to capital.

Profits are not greatly increased by shifting labor from a typical operator and family supply to a nonlimitational supply. With typical operator and family labor and nonlimitational capital ($12,369, table 8), net profit is $5,826; with nonlimitational labor and capital ($16,385, table 9), net profit is $6,283—an increase of only $457. An addition of 364 hours of labor and $4,016 in operating capital is required for this small increase in net profit. Farmers ordinarily would not hire additional labor and use more operating labor for such small returns.[16] However, the plans presented in table 9 might be used by farmers with sufficient family labor to attain the nonlimitational level of labor with no out-of-pocket cost. If this family labor has no profitable alternative use, imputation of the entire additional income to capital yields a return of about 11 percent.

PLANS WHERE LIVESTOCK BUILDINGS ARE NOT ON THE FARM

Many farms in the Ida-Monona soil area have sufficient buildings for grain and hay storage but lack ade-

[16] The analysis shows that, although labor is restrictive at high capital levels, the 160-acre farmer with a typical operator and family labor supply can increase profits little by hiring additional labor. With only 160 acres, the typical operator and family labor supply is adequate for nearly all profit-maximizing plans, even at high capital levels.

quate livestock buildings. In some cases, the farm has been operated primarily on a cash-grain basis. In others, the livestock buildings have deteriorated to a condition where they are of little use. Hence, the following question arises: Can a farmer afford to invest in buildings for livestock production and, if so, for what type of livestock? To answer this question building costs are treated as variable rather than as fixed and are included in the capital requirement for each livestock enterprise. Therefore, greater amounts of capital are required for each unit of livestock production. However, livestock enterprises are no longer limited by the typical or modal building sizes assumed in the preceding plans. Building space for livestock now can be expanded to a level consistent with profit maximization for the farm as a whole.

Table 10 includes optimum plans for a 160-acre farm which initially has no usable livestock buildings. The optimum plan with $3,300 operating capital is the same as that for the typical or modal livestock building situation (table 8). In both situations, limited funds are more profitably used in crop production than in livestock production. Livestock now are even less competitive with crops than in the typical or modal building situation, since capital requirements for livestock are increased by the amount of livestock building costs.

With an increase in operating capital to $6,600, it becomes profitable to invest in buildings for livestock production. Again, a two-litter hog system is the first livestock enterprise for which building investment is made because it gives higher returns on capital than other livestock enterprises. One major difference does exist between plans for the building situations of tables 8 and 10. With typical or modal buildings available, hog production is limited to 20 litters by building space and remaining operating capital is used for beef enterprises. In the situation where livestock buildings must be constructed, maximum profits result from expanding the hog building investment (and, hence, the extent of the hog enterprise) beyond the 20-litter size before investing in buildings for beef cattle. With $9,900 operating capital, hog production reaches a maximum of 45 litters (table 10). Some farmers lack the managerial ability for this scale of hog production and may choose a lower income plan with fewer hogs and including some other livestock enterprise.

With $13,200 in operating capital (table 10), March labor restricts further expansion of hog production and allows deferred-fed calves to enter the plan. Under either livestock building situation, deferred-fed calves give a higher return on operating capital than other beef enterprises. When operating capital is increased to $15,000 (table 10), deferred-fed yearlings also enter the program because they make efficient use of capital and March and November labor. Yet if the operator works about 25 more hours in November, he can maintain profits by producing 24 deferred-fed calves instead of 16 deferred-fed calves and 9 yearlings. As a practical step, he would likely simplify the feeding program in this manner. With nonlimitational operating capital ($17,191, table 10), however, considerable sacrifice in income would result from modifying the beef program in this way.

Table 10 shows that labor restrictions limit hog production at the higher capital levels, allowing beef enterprises to enter the plan. But, if labor is a nonlimitational resource and risk is not considered, maximum profits result from expanding hog production to the limits of operating capital, while producing no beef cattle. Table A-1 of the Appendix shows that 76 litters of pigs and no cattle are included in the optimum plan with $15,000 in operating capital and nonlimitational labor. Net profit for this plan is $8,862, an increase of $1,706 over the $15,000 operating capital situation of table 10. Despite the increased income, considerations of risk, labor and management suggest that this may not be a practical alternative for most farmers.

Net profits at each level of operating capital are higher under the typical or modal building situation

TABLE 10. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 160-ACRE SITUATION WHERE LIVESTOCK BUILDINGS MUST BE CONSTRUCTED.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$3,300	A,B,C land Capital	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	No livestock		5,315 bu. sold	$1,420
$6,600	A,B,C land Capital	Same cropping system as for $3,300 capital					Two-litter hog system	22 litters	3,184 bu. sold	$3,601
$9,900	A,B,C land Capital	Same cropping system as for $3,300 capital					Two-litter hog system	45 litters	1,070 bu. sold	$5,787
$13,200	A,B,C land Capital March labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	44 litters 17 head	197 bu. sold	$6,818
$15,000	A,B,C land Capital March labor Nov. labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves Deferred-fed yearlings	43 litters 16 head 9 head	0 bu. purchased or sold	$7,156
Nonlimitational capital=$17,191	A,B,C land March labor Sept. labor Oct. labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves Yearlings fed clippings	42 litters 15 head 14 head	0 bu. purchased or sold	$7,374

* Assuming an operator and family labor supply and building investment charged against livestock.

† Net profit=gross return−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

TABLE 11. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 160-ACRE SITUATION, WITH A COMM ROTATION ON THE ENTIRE FARM.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$3,300	A,B,C land Capital	A & B C	$COMM_3$ $COMM_3$	114 29	Corn Oats Hay‡	36 36 71	Two-litter hog system	7 litters	2,587 bu. sold	$ 384
$9,900	A,B,C land Capital March labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	47 litters 2 head	1,317 bu. purchased	$4,078
Nonlimitational capital = $24,996	A,B,C, land March labor Sept. labor	Same cropping system as for $3,300 capital					Two-litter hog system Calves fed clippings Beef cows	33 litters 34 head 22 head	1,805 bu. purchased	$6,238

* Assuming an operator and family labor supply and building investment charged against livestock.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

(table 8) than under the situation with no buildings initially on the farm (table 10). This is true because building construction costs are incurred in the latter situation. However, where greater amounts of funds are available, they can be used to increase building space, thereby raising the upper limit on net profits. In the typical or modal building situation, investment in additional livestock buildings is not permitted, and the size of livestock enterprises is restricted accordingly. Consequently, profits are held at low levels because long-run profit-maximizing combinations of enterprises cannot be adopted.[17]

In summary, the farmer on Ida-Monona soils with 160 acres and no buildings should order capital investment as follows: First, plant the entire farm to the crop rotations shown; second, invest in fertilization at a high rate; third, construct buildings for hogs and increase hog production to the limits of available labor; and fourth, construct buildings for beef enterprises and extend feeding to the limits of available labor. This order of investment also exists for the comparable 280-acre situation discussed later.

INCOME EFFECTS OF A HIGH-FORAGE ROTATION

Soil erosion may be controlled practically in one of two ways: (1) by using rotations with a high proportion of hay and pasture or (2) by using mechanical practices such as contouring and terracing. The first method permits only limited grain production and requires a large annual capital investment for livestock to utilize the forage. The second method requires a large initial capital investment for mechanical practices but allows more intensive land use. Both methods often are recommended with little consideration of the capital and other resources of the operator. For example, a high-forage rotation is sometimes recommended on an entire farm for erosion-control purposes. An operator lacking the managerial ability and capital resources for cattle or sheep production cannot efficiently process this forage. On the other hand, investment in terraces is sometimes suggested without regard for the large initial out-of-pocket expense involved.

An attempt is made to compare relative incomes from the two types of conservation systems if both are in operation for a long period. Table 11 shows the optimum plans and net income at three operating capital levels when a high-forage rotation ($COMM_3$) is used on the entire farm.[18] These results are compared with those of table 10 (for comparable capital levels), where more grain-intensive rotations are allowed through use of adequate mechanical practices. Of course, these situations represent only two possible levels of soil conservation in a continuum ranging from low soil loss to exploitive farming. However, the two methods analyzed represent alternatives in restricting soil loss to an economically feasible level.

Plans and incomes first are compared for the situations with $3,300 operating capital in tables 10 and 11. The high-forage plan (table 11) includes only about half the corn acreage of the low-forage plan (table 10). While per-acre grain yields are somewhat higher in the former plan, total grain output is reduced drastically. Less capital is required for crops in the high-forage system, leaving sufficient funds for seven litters of hog production; yet net income is $1,036 less than from the grain-intensive plan in which no hogs are produced.

A comparison of plans for the $9,900 operating capital level shows that the high-forage plan gives $1,709 less income ($4,078 compared with $5,787 from the low-forage plan of table 10). The livestock systems are similar, but grain is purchased in the high-forage plan while grain is sold in the low-forage plan. At the nonlimitational capital level the high-forage plan gives $1,136 less income ($6,238 compared with $7,374 from the low-forage plan); also, the high-forage plan includes enterprises utilizing large quantities of roughage (e.g., beef cows). Again, large quantities of grain must be purchased to support the livestock program.

Mechanical practices also have an advantage over high-forage rotations in conserving moisture in periods of short rainfall. Terracing and listing retard the rate of water runoff and retain extra moisture which is beneficial in dry years. Too, meadow in the rotation draws heavily on soil moisture. Therefore, in a high-forage rotation (such as COMM), grain yields follow-

[17] Profits at given capital levels would be higher in the typical or modal building situation (table 8) than in the situation with no buildings initially (table 10) if the same quantity of buildings were on the farm in both cases.

[18] As indicated in table 4 even a $COMM_3$ rotation requires some erosion-control practices on steeper slopes. To control erosion through a rotation alone would allow so little grain production as to be economically infeasible for most western Iowa farm situations.

ing two successive years of meadow may be reduced through lack of moisture.

In conclusion, mechanical practices (terracing, contouring and listing) with use of high-grain rotations appear more promising than high-forage cropping systems as economic methods of achieving soil erosion control in the area. The major obstacles to adoption of terracing appear to be lack of capital for installation and objections to farming over terraces once they are installed.[19] Some farmers may partially overcome the first obstacle by constructing terraces themselves, at least on the gentler slopes, using standard farm equipment where this is possible. Education is probably the main method of overcoming objections to farming terraced land.

PLANS TO REDUCE RISK

The Ida-Monona soil area is one of the high-risk sections of Iowa. Uncertain rainfall and a predominately corn-hog-feeder cattle economy cause income instability to be greater than in most parts of Iowa. Many farmers in this area would accept some sacrifice in average income to attain greater income stability. Hence, plans to reduce income variability are computed by forcing low-risk livestock enterprises into the program. Six dairy cows and 100 hens are the low-risk enterprises forced into the first plan of table 12; 15 beef cows and 100 hens are forced into the second plan of table 12. The net profit from these plans can be compared with the plan for $15,000 in operating capital (table 10). The situations are the same, except that enterprise diversification is included in table 12.

The first diversified plan of table 12 is practical for farmers who wish to minimize risk with little sacrifice in income. Here the livestock program is built around the basic dairy and poultry enterprises. Because labor requirements for dairy cows are high, labor restrictions are particularly important in determining the optimum plan. Only 31 litters of pigs are included (compared with 43 litters, table 10) because of high March labor requirements for both dairy cattle and hogs. Two beef-feeding enterprises are permitted by the remaining labor supply. Thus, the plan reduces risk through considerable diversification of products and timing of marketings. Dairy products and eggs are sold regularly throughout the year; hogs are marketed twice a year. The beef-feeding enterprises are small, and over 1,000 bushels of corn are sold for cash. The income from this highly diversified plan is only $397 less than for the higher risk plan of table 10. Farmers with heavy family obligations or high risk aversion may prefer the less risky plan, even though average annual income might be less. Labor particularly is restricting with dairy cows included in the plan. Therefore, if the family labor supply is larger than the quantities assumed, the livestock program may be expanded and net profit increased above the level shown in table 12.

Some farmers wish to reduce risk, but either dislike dairying or lack dairying facilities. For these individuals, beef cows may be included in the program (see plan 2, table 12). Since beef cows require little labor, the two-litter hog enterprise again expands to 43 litters. As a practical step, the farmer probably would feed out his own calves and reduce hogs accordingly. Net profit with beef cows in the plan is $6,876, only $280 less than from the higher risk plan of table 10 at the same $15,000 level of operating capital. The plan with beef cows lacks the wide diversification of the plan including dairy cows, but gives slightly higher net profit. A choice between the two plans of table 12 may hinge on labor supplies. The beef-cow plan is better suited for farmers with less than the typical operator and family labor supplies; dairy cattle are better adapted where labor is plentiful. Despite the fact that hay is limiting in both plans, a shift to rotations producing greater amounts of forage would depress net profit.

In all previous plans, the rotations have been fertilized at the third or highest rate. However, uncertain moisture conditions make the return on this investment somewhat uncertain. Hence, plans are computed where the third fertilization rate is omitted (see table 13). Comparison of these results with those of table 10 show the changes in plans and in net profit from using different fertilization rates. Since the two sets of plans (tables 10 and 13) follow the same pattern, explanations are not repeated. The major difference is that grain yields are lower under the second fertilization method. Therefore, corn must be purchased in the plans for higher capital levels of table 13. The optimum cropping pattern does not change. The same rotations maximize profits, but less

[19] Frey. op. cit. p. 978-9.

TABLE 12. OPTIMUM FARM PLANS WITH $15,000 OPERATING CAPITAL FOR A 160-ACRE SITUATION WHERE RISK-PRECAUTION IS TAKEN BY FORCING INTO THE PLAN (a) DAIRY AND POULTRY ENTERPRISES AND (b) BEEF COW AND POULTRY ENTERPRISES.*

Operating capital used	Limiting resources	Soil class	Cropping system: Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$15,000	A,B,C land	A & B	$CCOM_3$	114	Corn	69	Dairy cows	6 head	1,170 bu.	$6,759
	Capital	C	$CCOMM_3$	29	Oats	34	Poultry	100 hens	sold	
	March labor				Hay‡	40	Two-litter hog system	31 litters		
	May labor						Deferred-fed yearlings	11 head		
	Oct. labor						Yearlings fed clippings	7 head		
	Hay									
$15,000	A,B,C land	A & B	$CCOM_3$	114	Corn	69	Beef cows	15 head	955 bu.	$6,876
	Capital	C	$CCOMM_3$	29	Oats	34	Poultry	100 hens	sold	
	Hay				Hay‡	40	Two-litter hog system	43 litters		

* Assuming an operator and family labor supply and building investment charged against livestock.

† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

TABLE 13. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 160-ACRE SITUATION WHERE RISK-PRECAUTION IS TAKEN BY OMITTING HIGH FERTILIZATION AS A CROPPING PRACTICE.*

Operating capital used	Limiting resources	Cropping system: Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$3,300	A,B,C, land Capital	A & B C	$CCOM_2$ $CCOMM_2$	114 29	Corn Oats Hay‡	69 34 40	Two-litter hog system	2 litters	4,744 bu. sold	$1,208
$6,600	A,B,C land Capital	Same cropping system as for $3,300 capital					Two-litter hog system	23 litters	2,749 bu. sold	$3,271
$9,900	A,B,C land Capital	Same cropping system as for $3,300 capital					Two-litter hog system	45 litters	659 bu. sold	$5,432
$13,200	A,B,C land Capital March labor Nov. labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves	44 litters 18 head	180 bu. purchased	$6,416
$15,000	A,B,C land Capital March labor Oct. labor Nov. labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed calves Deferred-fed yearlings	44 litters 16 head 7 head	458 bu. purchased	$6,664
Nonlimitational capital = $18,438	A,B,C land March labor May labor Oct. labor	Same cropping system as for $3,300 capital					Two-litter hog system Deferred-fed yearlings Yearlings fed clippings	44 litters 11 head 18 head	614 bu. purchased	$6,844

* Assuming an operator and family labor supply and building investment charged against livestock.

† Net profit=gross return−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

fertilizer is used, and average income is lower. The sacrifice in income from shifting to the lower fertilization rate ranges from $212 at the $3,300 capital level to $530 when capital is nonlimitational. Many farmers, especially those short on funds, may choose a lower average income to avoid the risk associated with heavy fertilization practices.

PLANS FOR VARIOUS HOG-BEEF CATTLE PRICE RELATIONSHIPS

Recent history has shown that the ratios between hog and beef-cattle prices shift considerably from the average in some years. To estimate the changes in farm planning and income which accompany these price shifts, plans are computed for four situations of beef-cattle and hog prices: (1) above-average hog prices and average beef prices, (2) below-average hog prices and average beef prices, (3) average hog prices and below-average beef prices and (4) average hog prices and above-average beef prices.[20]

Optimum farm plans and net incomes for the four cattle-hog price relationships are presented in table 14. A single plan with $15,000 in operating capital is shown for each situation. These plans then are compared with the plan for $15,000 in operating capital (table 10). Except for cattle and hog prices, the

[20] "Average" cattle and hog prices (as shown in table 3) are those used in all previous situations. "Below-average" hog prices are $16.71 per hundredweight; "above-average" hog prices are $22.59 per hundredweight, based on changes in the hog-corn ratio. Cattle prices are adjusted by the margin between feeder and fat cattle prices. The "below-average" beef prices are based on the low price margin of the 1952-53 feeding period; "above-average" beef prices are based on the high price margin in the 1953-54 feeding period.

TABLE 14. OPTIMUM FARM PLANS WITH $15,000 OPERATING CAPITAL FOR A 160-ACRE SITUATION WITH (1) ABOVE-AVERAGE HOG PRICES AND AVERAGE BEEF PRICES, (2) BELOW-AVERAGE HOG PRICES AND AVERAGE BEEF PRICES, (3) AVERAGE HOG PRICES AND BELOW-AVERAGE BEEF PRICES AND (4) AVERAGE HOG PRICES AND ABOVE-AVERAGE BEEF PRICES.*

Operating capital used	Limiting resources	Cropping system: Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$15,000 (1)	A,B,C land Capital March labor Oct. labor Nov. labor	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	Two-litter hog system Deferred-fed calves Deferred-fed yearlings	44 litters 16 head 8 head	5 bu. purchased	$9,536
$15,000 (2)	A,B,C land Capital March labor Oct. labor Nov. labor	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	Two-litter hog system Deferred-fed calves Deferred-fed yearlings	43 litters 16 head 8 head	70 bu. sold	$5,526
$15,000 (3)	A,B,C land March labor	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	Two-litter hog system	47 litters	932 bu. sold	$5,922
$15,000 (4)	A,B,C land Capital March labor Oct. labor Nov. labor	A & B C	$CCOM_3$ $CCOMM_3$	114 29	Corn Oats Hay‡	69 34 40	Two-litter hog system One-litter hog system Deferred-fed calves Calves on pasture	9 litters 5 litters 28 head 23 head	1,022 bu. sold	$9,884

* Assuming an operator and family labor supply and building investment charged against livestock. See text for definitions of average, below-average and above-average beef and hog prices.

† Net profit=gross return−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.

‡ Includes rotation pasture.

assumptions underlying the plans of both tables are identical. Situation (1), table 14 assumes above-average hog prices and average beef-cattle prices. The optimum plan in this situation is practically indentical with that for average cattle and hog prices (see the plan for $15,000 in operating capital, table 10). Though hog production now is relatively more profitable, capital and labor limitations still restrict output to 44 litters. Thus, the major effect is one of increasing income by $2,380.

Situation (2), table 14 is computed for below-average hog prices and average beef-cattle prices. Again, the optimum plan is almost the same as for normal hog and cattle prices ($15,000 operating capital level, table 10). Though hog prices and profits are lowered, hogs still give a greater return on capital than the beef enterprises. Thus, the hog enterprise is maintained at 43 litters while income drops sharply from $7,156 with normal prices to $5,526 with below-average hog prices. Thus, optimum farm plans are quite stable when hog prices shift within the ranges considered (with price margins on cattle normal). However, incomes vary widely from changes in hog prices. These results help explain why hog production is sometimes unresponsive to shifts in hog prices; increasing or reducing hog production within a certain range of hog prices may provide lower profits than holding production constant. That is, the farmer may be operating at the "corner" of a discontinuous production possibility curve. For example, 43 or 44 litters are produced whether hog prices are below-average, average or above-average in the above situations. Of course, if hog prices are lowered sufficiently relative to cattle, hogs will be replaced by beef cattle in the plan. Such a price change is considered in a later situation for the 280-acre farm.

Situation (3), table 14 shows the optimum farm plan for average hog prices and below-average beef-cattle prices. Here the plan changes greatly from that for normal hog and cattle prices ($15,000 operating capital, table 10). Hogs become the only livestock enterprise, and income is reduced by $1,234.

Situation (4) table 14 assumes average hog prices and above-average beef-cattle prices. Again, the change from the plan with normal beef and hog prices is pronounced. Hogs are reduced from 43 to 14 litters per year, while beef-cattle production is doubled. Also, income takes a sharp upswing from $7,156 to $9,884—an increase of $2,728. Thus, if profits are to be maximized, a shift in cattle prices leads to substantial changes in livestock production on the individual farm. Many farmers (particularly small-scale producers) are sensitive to changes in price margins on feeder cattle. On the basis of these results, such decisions appear well-founded.

Key considerations in optimum farm planning are the ratios of resource requirements (labor, land, capital, building space, etc.) to net returns for each enterprise. Where hog prices were lowered relative to beef-cattle prices, the "order" of these resource-return ratios was unchanged between enterprises. However, when cattle prices were changed relative to normal hog prices, the ratios shifted in "order," resulting in a new optimum combination of enterprises.

INTERPRETATION OF MAXIMUM-PROFIT PLANS FOR 280-ACRE FARM SITUATIONS

The 280-acre situations to be investigated parallel closely the 160-acre situations already discussed. A typical operator and family labor supply[21] is used in most 280-acre situations, although planning and income effects of a nonlimitational labor supply also are studied. The two situations regarding livestock buildings are used; however, the typical or modal amount of building space is greater on the 280-acre farm than on the 160-acre farm.

Some differences do occur between the 160-acre and 280-acre situations with respect to soils and crops. The two farm sizes are not identical in proportions of soil types and slopes as indicated previously in table 1. The makeup of soils and slopes within soil classes (A, B, C and D) also differ. Soil classes B and C on the 280-acre farm contain a greater percentage of more sloping soils than do the same soil classes on the 160-acre farm. Also, the 280-acre farm contains 27 acres of D soils (over 20 percent in slope) while the 160-acre farm contains none. Since crop yields are adjusted by soil slope, net returns per rotation are changed slightly in the two farm-size situations. An additional change is that, because of risk considerations, the third or high fertilization rate is dropped as a cropping alternative in the 280-acre situations. These shifts cause some differences in cropping plans for similar 160-acre and 280-acre situations.

The first 280-acre situation considered is one in which resource restrictions approximate those on a representative 280-acre farm in the Ida-Monona soil area of western Iowa. Plans for other resource and price situations then are compared with this "typical" 280-acre situation. Where comparable 160-acre and 280-acre situations exist, differences or similarities in plans for the two farm sizes are emphasized.

PLANS FOR A "TYPICAL" SITUATION

Table 15 summarizes the optimum farm plans at various operating capital levels for a "typical" 280-acre situation. At the $6,000 capital level, soil classes C and D are not cultivated, and the limited capital is used for hog production.[22] That is, hog production gives slightly higher returns per dollar of operating capital than do crops grown on C and D land. The opposite was true in the "typical" 160-acre situation (table 8). Differences in soil proportions noted earlier, with the subsequent effect on yields and returns, shift the order of profitability between hogs and crops.

Since hogs and crops grown on C and D land are close competitors for use of capital, a choice between the two alternatives at low capital levels should be based on expected yields and prices. However, the sacrifices in income from choosing the lower income alternative are not large. With $6,000 in operating capital (table 15), the entire farm could be cropped and fewer hogs raised (7 litters) with a sacrifice of

[21] This labor supply refers to monthly quantities of operator and family or hired labor shown in table 2.

[22] Uncultivated cropland would be rented out on a crop-share or cash basis.

TABLE 15. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A "TYPICAL" 280-ACRE SITUATION.*

Operating capital used	Limiting resources	Cropping system: Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B land	A	$CCOM_2$	78	Corn	50	Two-litter hog system	34 litters	548 bu.	$2,813
	Capital	B	$CCOMM_2$	27	Oats	25			sold	
		C,D rented out‡		148	Hay§	30				
$12,000	A,B,C,D land	A	$CCOM_2$	78	Corn	105	Two-litter hog system	30 litters	2,292 bu.	$6,467
	Capital	B	$CCOMM_2$	27	Oats	56	One-litter hog system	13 litters	sold	
	March labor	C	$CCOMM_2$	121	Hay§	92	Deferred-fed calves	11 head		
	April labor	D	$COMM_2$	27						
	May labor									
$18,000	A,B,C,D land	A	$CCOM_2$	78	Corn	101	Two-litter hog system	10 litters	2,505 bu.	$7,840
	Capital	B	$CCOMM_2$	27	Oats	57	One-litter hog system	21 litters	sold	
	March labor	C	$CCOMM_2$	92	Hay§	95	Deferred-fed calves	22 head		
	April labor	C	$COMM_2$	29			Beef cows	23 head		
	May labor	D	$COMM_2$	27						
	Oct. labor									
Nonlimitational capital = $19,479	A,B,C,D land	A	$CCOM_2$	78	Corn	87	Two-litter hog system	12 litters	1,310 bu.	$8,043
	March labor	B	$CCOMM_2$	27	Oats	62	One-litter hog system	18 litters	sold	
	May labor	C	$COMM_2$	121	Hay§	104	Deferred-fed calves	28 head		
	Sept. labor	D	$COMM_2$	27			Beef cows	22 head		
	Oct. labor						Yearlings on pasture	8 head		
	Hay									

* Assuming an operator and family labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm.

† Net profits=gross returns−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit. Return from cropland rented out is not included in net profit.

‡ Cropland rented out on a crop-share or cash basis.

§ Includes rotation pasture.

only $300 in income. This plan may be more attractive to farmers with a low risk preference.

Another production alternative may allow C and D soils to be cropped with little or no loss in income. Farmers with limited operating capital might cultivate all cropland and reduce labor inputs and costs per acre (corn could be cultivated only once or twice, lower rates of fertilizer applied, etc.). This method might provide greater income than intensively cultivating less land. With this plan, the 280-acre farmer with $6,000 in operating capital (table 15) would continue to produce nearly 30 litters of hogs; however, instead of intensively cropping 105 acres, he would cultivate 253 acres less intensively. Yields and cost data are not available for computation of returns from such a plan. However, observation tends to support this alternative as perhaps the most practical use of limited funds.

An increase in operating capital to $12,000 (table 15) allows all cropland to be planted. The rotation on B land differs from that in the optimum 160-acre cropping plan for the reason given earlier: Differences in composition of soils within soil classes cause a shift in relative profitability of the rotations. On B soils, therefore, CCOMM is optimum for the 280-acre situation, while CCOM is optimum for 160-acre situations. With $12,000 operating capital (table 15) three livestock enterprises are dovetailed into the plan to fit labor supplies which become restricting in 3 months. Labor restrictions are more important in determining optimum farm plans in the 280-acre situations than in the 160-acre situations. Even at the lower capital levels for the 280-acre situations, several months of labor limit the selection of livestock enterprises.

When capital is increased to $18,000 (table 15), October labor also becomes limiting. Thus, $COMM_2$ replaces 29 acres of $CCOMM_2$ on C soils, and beef cows enter the plan at $18,000 operating capital because both of these enterprises have a low October labor requirement per dollar of net return. With nonlimitational capital ($19,479) C soils are shifted completely from $CCOMM_2$ to $COMM_2$. In addition to having a lower October labor requirement, $COMM_2$ furnishes more hay than $CCOMM_2$ (hay is a limiting resource with nonlimitational capital, and grain can be purchased). Pasture-fed yearlings enter the plan because they use no October labor.

The cropping plans presented in table 15 appear quite complex, since two or three rotations often enter a single farm program. These rotation systems are intended only as guides. As mentioned earlier, modification would be required to meet practical problems of fencing and field operations. However, the plans do suggest the intensity with which various soil groups should be cropped if profits are to be maximized. All cropland is fertilized at the second rate—the highest level allowed in programming the 280-acre farm. Again, fertilization has a high priority in the use of investment funds.

A comparison between the 160-acre situation (table 8) and the 280-acre situation (table 15) shows that, at low capital levels, livestock enterprises enter the optimum plan in the same order. The two-litter hog system enters the livestock plan first at low capital levels, followed by deferred-fed calves. However, as capital increases, livestock plans in the two situations diverge because of labor, hay and building space restrictions.

As noted, operator and family labor restrictions play a vital part in determining optimum plans for the 280-acre situations. Farmers with large family labor supplies, or those willing to work extra hours in critical months, could increase incomes above those of table 15. The possibilities for increasing incomes through use of hired labor are discussed later.

Table 15 suggests that farmers with little capital might realize high returns on borrowed capital. When operating funds are doubled (from $6,000 to $12,000, table 15), net returns are more than doubled (from $2,813 to $6,467, table 15).[23] Additional capital in-

[23] The entire increase in income cannot be imputed to additional capital; other resources also are used more fully.

TABLE 16. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WHERE LABOR IS NONLIMITATIONAL.*

Operating capital used	Limiting resources	Cropping system: Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B land	A	$CCOM_2$	78	Corn	50	Two-litter hog system	34 litters	548 bu.	$2,813
	Capital	B	$CCOMM_2$	27	Oats	25			sold	
		C,D rented out‡		148	Hay§	30				
$12,000	A,B,C,D land	A	$CCOM_2$	78	Corn	105	Two-litter hog system	60 litters	1,300 bu.	$7,338
	Capital	B	$CCOMM_2$	27	Oats	56	Deferred-fed calves	2 head	sold	
	Hog space	C	$CCOMM_2$	121	Hay§	92				
		D	$COMM_2$	27						
$18,000	A,B,C,D land	A	$CCOM_2$	78	Corn	108	Two-litter hog system	60 litters	0 bu.	$9,616
	Capital	B	$CCOM_2$	27	Oats	57	Deferred-fed calves	29 head	purchased	
	Hog space	C	$CCOMM_2$	121	Hay§	88	Beef cows	8 head	or sold	
	Hay	D	$COMM_2$	27						
$24,000	A,B,C,D land	Same cropping system as for $18,000 capital					Two-litter hog system	60 litters	1,717 bu.	$11,116
	Capital						Deferred fed calves	62 head	purchased	
	Hog space						Beef cows	3 head		
	Hay									
$30,000	A,B,C,D land	A	$CCOM_2$	78	Corn	87	Two-litter hog system	60 litters	4,016 bu.	$11,784
	Capital	B	$CCOMM_2$	27	Oats	62	Deferred-fed calves	83 head	purchased	
	Hog space	C	$COMM_2$	121	Hay§	104	Calves fed clippings	6 head		
	Hay	D	$COMM_2$	27						

* Assuming a nonlimitational labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm.

† Net profit=gross return−(variable costs+taxes+insurance+building repair+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit. Return from cropland rented out is not included in net profit.

‡ Cropland rented out on a crop-share or cash basis.

§ Includes rotation pasture.

creases net profit but at a diminishing rate. This same pattern held true for the "typical" 160-acre situation (table 8). These results have important implications both for farmers who are short on capital and for credit agencies making production loans in the Ida-Monona soil area.

PLANS FOR A NONLIMITATIONAL LABOR SUPPLY

Family labor supplies restrict farm plans and profits in the 280-acre "typical" situation (table 15). As a guide to farmers who might hire additional labor, plans are computed for a nonlimitational labor supply (table 16). Comparisons of net profit from typical operator and family labor situations (table 15) and nonlimitational labor situations (table 16) are made at each level of operating capital. Returns on additional labor then are computed and compared with wage rates to determine if labor may be profitably hired.

The plan for $6,000 in operating capital is the same for the nonlimitational labor situation (table 16) as for the "typical" situation (table 15); labor is not a limiting resource at this capital level. However, plans and incomes in the two situations diverge as capital is increased to $12,000 and more. With added capital, hog production expands to the limits of building space (60 litters) and the number of deferred-fed calves increases (table 16). Calves fed on clippings enter the plan at the $30,000 capital level because this enterprise utilizes the limited forage supply efficiently.

The plans of table 15 (for operator and family labor supply) and table 16 (for a nonlimitational labor supply) now are compared for capital levels of $12,000 and $18,000. The relevant question is whether a farmer can profitably hire labor to make the shift between plans. Earlier analysis showed that operators on a 160-acre unit generally could not increase profits by hiring labor in a similar situation (compare tables 8 and 9). For the larger 280-acre farm, however, the conclusions are different. At the $12,000 level of operating capital, an additional 132 hours of spring labor (approximately 45 hours each in March, April and May) would allow a shift to the nonlimitational labor plan shown. The average return on the added labor would be $6.60 per hour. Part-time labor for these 3 months probably could be hired for about $1 to $1.50 per hour, leaving a net return to the operator of about $5 to $5.50 per hour. Many farm operators would willingly hire labor or work extra hours to realize this rate of return.

At the $18,000 operating capital level, 378 hours of additional labor permit a shift to the higher income plan (compare tables 15 and 16). The average return on this labor, before wages are deducted, is $4.70 per hour. Again, many farmers would hire labor at this rate of return. Some farmers with even more capital (e.g., $24,000 to $30,000) could profitably hire a man half-time or full-time year-around to reach the high income plans of table 16.

Large quantities of feed grain are purchased when capital is at high levels and labor is nonlimitational (table 16). Because of the risk associated with feed grain purchase, many farmers do not expand livestock production beyond the limits imposed by grain produced on the farm. Thus, an optimum plan with $24,000 in operating capital is computed where livestock are limited to the farm grain supply (table 17). Comparison of tables 16 and 17 shows that a farmer with $24,000 in operating capital sacrifices $852 in income by restricting livestock production to supplies of grain produced on the home farm. Greater income sacrifices occur from restricting the plan to grain produced on the home farm when the level of capital is greater than $24,000. On the other hand, most farmers on 160- and 280-acre farms can raise sufficient grain (assuming use of mechanical erosion-control practices) to handle the livestock production consistent with usual labor, capital and building restrictions. Only at extremely high resource levels must feed grain

TABLE 17. OPTIMUM FARM PLAN WITH $24,000 OPERATING CAPITAL FOR A 280-ACRE SITUATION WHERE LIVESTOCK PRODUCTION IS LIMITED TO HOME-GROWN GRAIN.*

Operating capital used	Limiting resources	Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$24,000	A,B,C,D land	A	CCOM$_2$	78	Corn	108	Two-litter hog system	60 litters	0 bu. purchased or sold	$10,264
	Hog space	B	CCOM$_2$	27	Oats	57	Deferred-fed calves	27 head		
	Feed grain	C	CCOMM$_2$	121	Hay‡	88	Beef cows	17 head		
	Hay	D	COMM$_2$	27						

* Assuming a nonlimitational labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm.
† Net profit=gross return−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

be purchased, and farmers in these situations ordinarily can withstand the added risk associated with grain buying.

Two sets of plans were computed where both livestock building space and labor were nonlimitational. In the first set of plans livestock enterprises were limited to grain produced on the home farm, while in the second set of plans corn could be purchased. Details of these plans are found in tables A-2 and A-3 of the Appendix. Many farmers, even those with the necessary resources, would not accept the high risk associated with the large hog enterprises in these plans.

PLANS WHERE LIVESTOCK BUILDINGS ARE NOT ON THE FARM

If buildings are rundown or nonexistent, can new buildings for livestock production be profitably constructed on a 280-acre farm? To answer this question, optimum plans are developed for a situation in which no livestock buildings are present on the farm initially (table 18).

With $6,000 in operating capital, a difference appears in priority of investment where buildings "are" or "are not" present on the farm (compare tables 15 and 18). In the typical or modal building situation (table 15), hog production precedes crop production on C and D soils in priority of returns on investment funds. With buildings not present (table 18) all land, including C and D soils, is planted before livestock are produced. Thus, when buildings are not initially available for livestock production, crops regain the advantage of the highest return per dollar of operating capital.

With operating capital at $12,000 and over (table 18), crop production does not use all the funds. Remaining capital then can be used profitably for investment in livestock buildings and livestock production. The optimum livestock enterprises follow the same pattern as in the "typical" 280-acre situation (table 15). In both cases, hogs enter the plan first at low capital levels and are followed by deferred-fed calves, beef cows and yearlings fed on pasture as capital increases. However, at comparable levels of operating capital, net profits are lower when livestock buildings must be constructed from available funds. Diversion of capital to buildings reduces the number of livestock produced, and hence, lowers net profits.

In the 160-acre situations discussed earlier (see tables 8 and 10), operators with nonlimitational capital obtain maximum profits by increasing hog building space beyond the typical or modal supply. With 280 acres, however, labor is so restricting at high capital levels that increasing buildings beyond the typical or modal amount is unprofitable.

Plans also are computed for a situation where

TABLE 18. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WHERE LIVESTOCK BUILDINGS MUST BE CONSTRUCTED.*

Operating capital used	Limiting resources	Soil class	Cropping system: Rotation	Cropping system: Acres	Crop acreage: Crop	Crop acreage: Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B,C,D land	A	CCOM$_2$	78	Corn	105	Two-litter hog system	9 litters	6,103 bu. sold	$2,223
	Capital	B	CCOMM$_2$	27	Oats	56				
		C	CCOMM$_2$	121	Hay‡	92				
		D	COMM$_2$	27						
$12,000	A,B,C,D land	A	CCOM$_2$	78	Corn	105	Two-litter hog system	42 litters	2,459 bu. sold	$6,066
	Capital	B	CCOMM$_2$	27	Oats	56	One-litter hog system	5 litters		
	March labor	C	CCOMM$_2$	121	Hay‡	92				
	April labor	D	COMM$_2$	27						
$18,000	A,B,C,D land	A	CCOM$_2$	78	Corn	101	Two-litter hog system	18 litters	2,146 bu. sold	$7,060
	Capital	B	CCOMM$_2$	27	Oats	57	One-litter hog system	18 litters		
	March labor	C	CCOMM$_2$	97	Hay‡	95	Deferred-fed calves	20 head		
	April labor	C	COMM$_2$	24			Beef cows	9 head		
	May labor	D	COMM$_2$	27						
	Oct. labor									
Nonlimitational capital = $24,000	A,B,C,D land	A	CCOM$_2$	78	Corn	89	Two-litter hog system	12 litters	1,480 bu. sold	$8,023
	Capital	B	CCOMM$_2$	27	Oats	61	One-litter hog system	17 litters		
	March labor	C	CCOMM$_2$	13	Hay‡	103	Deferred-fed calves	27 head		
	April labor	C	COMM$_2$	108			Beef cows	23 head		
	May labor	D	COMM$_2$	27			Yearlings on pasture	8 head		
	Sept. labor									
	Oct. labor									

* Assuming an operator and family labor supply and building investment charged against livestock.
† Net profit=gross return−(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

TABLE 19. OPTIMUM FARM PLANS WITH $18,000 OPERATING CAPITAL FOR A 280-ACRE SITUATION WHERE RISK PRECAUTION IS TAKEN BY FORCING DAIRY COWS AND POULTRY INTO THE PLAN.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$18,000	A,B,C,D land	A	CCOM2	78	Corn	105	Dairy cows	10 head	898 bu.	$7,862
	Capital	B	CCOMM2	27	Oats	56	One-litter hog system	56 litters	sold	
		C	CCOMM2	121	Hay‡	92	Two-litter hog system	4 litters		
		D	COMM2	27			Poultry	300 hens		

* Assuming that labor may be hired for $1 per hour; a typical or modal set of buildings exists on the farm; livestock limited to buildings on the farm.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

buildings are not present on the farm and labor is nonlimitational (see table A-4 in the Appendix). In this situation, construction of hog building space far beyond the typical or modal supply is profitable. Few farmers, however, would adopt a plan with the scale of hog production shown in table A-4.

PLANS TO REDUCE RISK

As mentioned earlier, many farmers in the Ida-Monona soil area accept some sacrifice in income to obtain greater income stability. Since income variability may be reduced by including low-risk enterprises in the farm plan, an optimum plan is computed (with $18,000 in operating capital) where 10 dairy cows and 300 hens are forced into the program. Dairy and poultry require large quantities of labor year-around, and labor becomes restricting in several months on 280 acres.

By hiring labor when needed, income from the low-risk plan including dairy and poultry (table 19) is maintained at approximately the same level as in the "typical" 280-acre situation ($18,000 operating capital level, table 15). However, if the two situations are made comparable by permitting labor hiring in the typical situation, the low-risk plan (table 19) brings approximately $1,500 less return. Thus, dairy production on 280 acres appears less practical as a means of stabilizing income than on 160 acres. A greater sacrifice in income results from shifting to the lower risk plan on 280 acres. While dairying reduces risk, there is a large measure of uncertainty in hiring seasonal labor. Practically, then, the dairy cow diversification plan for a 280-acre farm may have little advantage in income stability over the "typical" plan of table 15.

These results do not imply that dairying is unprofitable on all farms in the area. Development of a grade A milk market might make dairying quite profitable in localized areas. For farmers in these areas who have year-around hired labor and have expanded investment in stock and equipment, volume production of grade A milk would be feasible. However, since relatively few farms in the area currently have the market or resources, a widespread shift toward grade A milk does not appear in prospect.

PLANS FOR LOWERED HOG PRICES

In the 160-acre situation, reduction of hog prices to $16.71 per hundredweight (with cattle prices at the average levels of table 3) had little effect on optimum farm plans; the major effect was lower net profit. During 1955, however, hog prices declined even lower. Hence, optimum plans were computed for the 280-acre farm with hog prices at $15.43 per hundredweight, while cattle prices remained at the average level (table 20).

Under these price conditions, deferred-fed calves brought higher returns on capital than did hogs. Hence, deferred-fed calves entered the plan first at low levels of operating capital. The change in product price ratios was sufficiently great to shift the "order" of profitability among enterprises. In addition, net profits were considerably lower under this set of hog prices.[24]

[24] It should be recognized that the reduction in income from lower hog prices is minimized in the plans of table 20. These plans give maximum income with lowered hog prices, since resources are optimally allocated under these price conditions. However, a farmer using another plan (e.g., one which is optimum under "typical" conditions, table 15) would experience a greater decline in income when hog prices fall. Most farmers of the area did not anticipate a fall in hog prices to the levels reached in the fall of 1955. Thus, in general, they absorbed much larger losses than indicated by comparison of tables 15 and 20. A combination of low livestock prices, high costs and unfavorable weather conditions were responsible for greatly reduced incomes in the area in 1955.

TABLE 20. OPTIMUM FARM PLANS AT TWO OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WITH LOW HOG PRICES AND AVERAGE BEEF PRICES.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$12,000	A,B,C,D, land	A	CCOM2	78	Corn	105	One-litter hog system	19 litters	3,525 bu.	$4,989
	Capital	B	CCOMM2	27	Oats	56	Deferred-fed calves	32 head	sold	
	Oct. labor	C	CCOMM2	121	Hay‡	92				
		D	COMM2	27						
$18,000	A,B,C,D land	A	CCOM2	78	Corn	101	One-litter hog system	28 litters	2,622 bu.	$7,034
	Capital	B	CCOMM2	27	Oats	57	Deferred-fed calves	24 head	sold	
	March labor	C	CCOMM2	95	Hay‡	95	Beef cows	23 head		
	May labor	C	COMM2	26						
	Oct. labor	D	COMM2	27						

* Assuming an operator and family labor supply and a typical or modal set of livestock buildings; livestock limited to buildings on the farm. See text for definition of low and average livestock prices.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

CONCLUSIONS

The main conclusions from the analysis may be summarized briefly as follows:

1. Programs suggested to farmers should vary between farms, depending on the availability of capital, labor and other resources.

2. On both 160- and 280-acre farms, the optimum cropping plans include grain-intensive rotations which are fertilized heavily and supplemented with mechanical practices to control erosion. This method of erosion control permits greater profits in most situations than use of high-forage rotations.

3. Under the average price relationships studied, profits are maximized by investing initially in crops and fertilizer, followed by hogs and cattle, respectively.

4. In general, farmers in the Ida-Monona soil area must accept some sacrifice in income to obtain greater stability of income. Including a dairy or beef-cow enterprise in the farm plan reduces risk with little sacrifice in income on farms of 160 acres. However, because of labor restrictions, dairying is a questionable method for spreading risk on 280-acre farms.

5. Starting at low capital levels, additional increments of capital increase net profit but at a diminishing rate. Thus, farmers with restricted capital supplies probably have more productive uses for borrowed capital than farmers with ample funds.

6. Use of hired labor usually is not profitable in 160-acre situations with other resources held at the typical or modal levels. Returns on hired labor on 280-acre farms are sufficiently high to permit profitable use of part-time, and in some cases full-time, hired labor.

7. Hog prices can shift considerably from the "normal" relationship with beef-cattle prices without altering the optimum livestock plan; income, however, fluctuates widely and in the same direction as hog prices. Changes in price margins for beef cattle require major shifts in farm plans for maximum profits.

LIMITATIONS

Care should be used in interpreting the plans presented in this study. The results are applicable to a single area—the Ida-Monona soil area of western Iowa. Inferences from the plans presented should be made only to the population of farms in the area which approximately meets the resource restrictions specified. Changes in the level of prices assumed generally will not alter the optimum farm plans, providing the price changes are roughly proportional for all factors and products; however, net profits will be directly affected by changes in the price level. Thus, while the plans presented may be quite stable over a wide range of prices, the net profit figures may deviate substantially from those shown.

APPENDIX

TABLE A-1. OPTIMUM FARM PLAN WITH $15,000 OPERATING CAPITAL FOR A 160-ACRE SITUATION WHERE LABOR IS NONLIMITATIONAL.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$15,000	A,B,C land	A & B	$CCOM_3$	114	Corn	69	Two-litter hog system	76 litters	1,823 bu.	$8,862
	Capital	C	$CCOMM_3$	29	Oats	34			purchased	
					Hay ‡	40				

* Assuming a nonlimitational labor supply and building investment charged against livestock.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

TABLE A-2. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WHERE LABOR AND BUILDINGS ARE NONLIMITATIONAL.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B land	A	$CCOM_2$	78	Corn	50	Two-litter hog system	34 litters	548 bu.	$2,813
	Capital	B	$CCOMM_2$	27	Oats	25			sold	
		C,D rented out‡		148	Hay§	30				
$12,000	A,B,C,D land	A	$CCOM_2$	78	Corn	105	Two-litter hog system	63 litters	1,179 bu.	$7,552
	Capital	B	$CCOMM_2$	27	Oats	56			sold	
		C	$CCOMM_2$	121	Hay§	92				
		D	$COMM_2$	27						
$18,000	A,B,C,D land	A	$CCOM_2$	78	Corn	108	One-litter hog system	72 litters	0 bu.	$10,713
	Capital	B	$CCOM_2$	27	Oats	57	Beef cows	8 head	purchased	
	Feed grain	C	$CCOMM_2$	121	Hay§	88			or sold	
		D	$COMM_2$	27						
Nonlimitational capital = $22,253	A,B,C,D land	Same cropping system as for $18,000 capital					One-litter hog system	70 litters	0 bu.	$11,916
	Feed grain						Beef cows	26 head	purchased	
	Hay								or sold	

* Assuming nonlimitational labor and livestock building space; grain cannot be purchased.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest should be deducted from net profit. Returns from cropland rented out are not included in net profit.
‡ Cropland rented out on a crop-share or cash basis.
§ Includes rotation pasture.

TABLE A-3. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WHERE LABOR AND BUILDINGS ARE NONLIMITATIONAL.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B land Capital	A B C,D rented out‡	CCOM$_2$ CCOMM$_2$ 	78 27 148	Corn Oats Hay§	50 25 30	Two-litter hog system	34 litters	548 bu. sold	$2,813
$12,000	A,B,C,D land Capital	A B C D	CCOM$_2$ CCOMM$_2$ CCOMM$_2$ COMM$_2$	78 27 121 27	Corn Oats Hay§	105 56 92	Two-litter hog system	63 litters	1,179 bu. sold	$7,552
$18,000	A,B,C,D land Capital	A B C D	CCOM$_2$ CCOM$_2$ CCOMM$_2$ COMM$_2$	78 27 121 27	Corn Oats Hay§	108 57 88	One-litter hog system	80 litters	739 bu. purchased	$10,932
$24,000	A,B,C,D land Capital	Same cropping system as for $18,000 capital					One-litter hog system	100 litters	2,775 bu. purchased	$13,187
$30,000	A,B,C,D land Capital	Same cropping system as for $18,000 capital					One-litter hog system	121 litters	4,811 bu. purchased	$15,479

* Assumptions same as for table A-2, except that grain can be purchased.
† Net profit=gross returns—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit. Returns from cropland rented out are not included in net profit.
‡ Cropland rented out on a crop-share or cash basis.
§ Includes rotation pasture.

TABLE A-4. OPTIMUM FARM PLANS AT VARIOUS OPERATING CAPITAL LEVELS FOR A 280-ACRE SITUATION WHERE LIVESTOCK BUILDINGS MUST BE CONSTRUCTED.*

Operating capital used	Limiting resources	Cropping system: Soil class	Rotation	Acres	Crop acreage: Crop	Acres	Livestock program: Enterprise	Size	Corn purchased or sold	Net profit†
$6,000	A,B,C,D land Capital	A B C D	CCOM$_2$ CCOMM$_2$ CCOMM$_2$ COMM$_2$	78 27 121 27	Corn Oats Hay‡	105 56 92	Two-litter hog system	9 litters	6,103 bu. sold	$2,223
$12,000	A,B,C,D land Capital	Same cropping system as for $6,000 capital					Two-litter hog system	52 litters	1,439 bu. sold	$6,208
$18,000	A,B,C,D land Capital Feed grain	A B C D	CCOM$_2$ CCOM$_2$ CCOMM$_2$ COMM$_2$	78 27 121 27	Corn Oats Hay‡	108 57 88	Two-litter hog system One-litter hog system	44 litters 31 litters	0 bu. purchased or sold	$9,378
$24,000	A,B,C,D land Capital Feed grain	Same cropping system as for $18,000 capital					One-litter hog system Beef cows	72 litters 11 head	0 bu. purchased or sold	$10,876
Nonlimitational capital = $28,562	A,B,C,D land Feed grain Hay	Same cropping system as for $18,000 capital					One-litter hog system Beef cows	70 litters 26 head	0 bu. purchased or sold	$11,916

* Assuming a nonlimitational labor supply and building investment charged against livestock; grain cannot be purchased.
† Net profit=gross return—(variable costs+taxes+insurance+building repairs+depreciation on machinery and buildings). If operating capital is borrowed, the interest charge should be deducted from net profit.
‡ Includes rotation pasture.

TABLE A-5. FIXED COSTS FOR TWO FARM SIZE GROUPS IN WESTERN IOWA.*

Item	140-199 acres					260-359 acres				
	1955	1954	1953	1952	1951	1955	1954	1953	1952	1951
Taxes, interest, insurance and building repairs	$ 986	$1,123	$1,085	$1,096	$ 866	$1,500	$1,557	$1,786	$1,331	$1,598
Machinery depreciation	1,057	1,019	993	887	865	1,513	1,418	1,370	1,292	1,194
Building depreciation	354	319	314	277	214	500	592	407	305	284
Total fixed costs†	$2,397	$2,461	$2,392	$2,260	$1,945	$3,513	$3,567	$3,563	$2,928	$3,076

* Taken from "Iowa Farm Record Summary" for western Iowa.
† The 1955 total fixed costs for the two farm size groups 140-199 and 260-359 acres are used as estimates for 160- and 280-acre farms in this study.